STUDIES ON DYNAMICS OF ESTABLISHING A BOTANICAL DIVERSITY PARK

Synopsis of the proposed work for the award of degree

DOCTOR OF PHILOSOPHY IN BOTANY

Submitted by

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INTRODUCTION

Cities provide large areas for residential support to the ever increasing population causing a major threat to local flora and fauna. Growing anthropogenic interference has caused irreversible damage to regional biodiversity. Fractured or damaged botanical diversity results in loss of plants specific to that region and so also causing loss to fauna and microbial population related to plant species (Oleyar et al. 2008). It is a well established fact that changes in botanical diversity could cause long lasting change in environmental conditions leading to unwarranted climatic changes **(**Nagendra et al. 2010**).**

Climate change is a major factor for the growth and development of biodiversity including flora, microorganisms and fauna (Schild 2007). Climate change at Himalayan region covering most parts of Nepal impacts negatively on the vegetation of that area. It has been observed that plant shows negative response for temperature (Gaire et al. 2011).

Study of ecosystem dynamics should be considered as a serious issue as trees are decreasing rapidly due to fast urbanization, development of industries and residential colonies. Increasing human population and its activities exert pressure on biodiversity causing it to fragment and thus threatening most of the species out of existence (Muthuramkumar et al. 2006). To determine the dynamics and structure of a community two main parameters should be taken into consideration qualitative properties and quantitative properties of an ecosystem (Harper et al. 2007).

Agra is semiarid region rich in its biodiversity of the flora. However, over a period because of urbanisation, and heavy pollution of river Yamuna several natural ecosystems have taken a beating and the city has lost many of its plant and animal species. Agra, once upon a time was famous for its many *Tals*, which have now been land filled and taken over by builders.

Many years back during monsoons small pockets of water-filled bodies used to develop on the banks of Yamuna, where Pteridophytes as *Opheoglossum, Equisetum, Selaginella* and Bryophytes as *Marchantia, Plagiochasma*, and *Riccia* grew abundantly. Population of many

herbs as *Cleome gynandra* (Sanskrit:*Ajagandha*), *Boerhavia diffusa* (Punernava), *Pedalium* (Bada Ghokuru), *Citrullus colosynthis* (Indrayan) to name a few, are getting drastically effected due to increased anthropogenic pressure. Tree species (*Tamarix aphylla, Pithecellobium, Salvadora, Tacomella undulata, etc.*) once dominating this region are also affected due to uprooting invading exotic species as *Prosopis juliflora.* This dwindling of plant species is adversely affecting fauna as well.

By considering all these issues which are related to our own ecosystem and climatic problems a biodiversity park is being established by Dayalbagh Educational Institute. It is being expected that this will have great impact on the conservation of flora and fauna. These local actions at the city level will reach far beyond its boundaries and can affect biodiversity at the global level. A brief description of the park is as following:

BIODIVERSITY PARK: LAB ON LAND

. Work on establishing a biodiversity park was started in 2014. Following sections are proposed to be developed:

i. ***Bougainvillea* garden**: It contains plantations of *Bougainvillea*. This garden attracts many butterflies therefore it is the centre of attention for visitors as situated at the entry of Park.

ii. **Succulent and Gymnosperm garden**: It contains plants that are adapted to dry conditions. It represents the adaptability of xerophytes and gymnosperms for arid environment.

iii. **Birds and Butterfly garden**: This section of the park represents the plantations which provide basic niches for the birds and butterflies. Plants growing in this section are specifically attractive for the birds and butterflies and beneficial in maintaining their population which otherwise do not get proper food due to urbanization and are being threatened.

iv. **Multigrafted and Rare plants**: This area of park contains those species which are grafted and rare in their occurrence.

v. **Palm plantation**: Collection of palms will be educative and attract fauna specific to these plants.

vi. **Arboretum 1 and 2 (types of tree species**): Trees are essential part of an ecosystem which maintains the diversity of different varieties of dependent plants, fauna and micro organisms. Hence an arboretum is proposed to be established in park which contains different economically and environmentally important tree species e.g. Chandan (*Santalum species*), *Moringa* (senjan), Jamun (*Syzygium cumini*), *Tectona* (sagvan), *Aegle* (bel), *Azadirachta* (neem), *Terminalia catappa* (jangali badam)) etc.

vii. **Tropical fruit garden**: It contains edible fruits like species of Citrus, Phalsa (*Grewia asiatica*), Mango (*Mangifera indica*), Pomegranate (*Punica granatum*), Guava (*Psidium guajava*), Chikoo or Sapodilla (*Manilkara zapota*), Ber (*Ziziphus jujube*), Anjeer (*Ficus carica*), sharifa (*Annona squamosa)*, Jamun (*Syzygium cumini*) etc.

viii. **Temperate fruit garden**: This region of park contains fruits which are growing in temperate areas like Aadu *(Prunus persica*), Lokhat (*Eriobotrya japonica*), Nashpati (*Pyrus parifolia*), Alubukhara (*Prunus species*) etc.

Besides all these efforts which are being done to conserve and reintroduce the species which have extinct, it has been observed that the survival rate of plants in the park is very poor. The population of plants is declining since last few years. Therefore, this work is expected to determine the factors responsible for better survival rate of plants.

OBJECTIVES

Since number of plants in the Biodiversity Park is decline due to some stress conditions therefore the objectives of the study are such which can solve the problem. These are as following:

1) *Ex situ* experimentation to determine soil quality
2) *Ex situ* experimentation to determine water quality.
3) Quantify terrestrial carbon sequestration.

REVIEW OF LITERATURE

There are many factors which contribute to the development of a forest ecosystem from which the nutrient cycling is critically important. The study of nutrient cycling is the major criteria by which one can determine the whole dynamics of an ecosystem. It is helpful to understand the nutrient need; rates of nutrient turnover, loss and addition of nutrient and its uptake (Cole et al.1980).

The soil contains large fraction of carbon found in terrestrial ecosystem. The soil has such a huge amount of carbon that can be compare with the carbon accumulated in the vegetation and atmosphere therefore soil has carbon as one of the major constituent among all other nutrients. Since carbon remains in the soil for long period of time hence there is continuity in the cycling process of the carbon and it is often referred to as sequestered (Swift et al. 2001).

Since terrestrial ecosystem contains most of our vegetation therefore it is necessary to study the dynamics of carbon on terrestrial land. BIOME BGC model is one of the commonly used models for carbon sequestration. It is corroborated type of model which mainly includes three parameters to be taken into concern. These parameters are leaf area index (LAI), net ecosystem productivity (NEP) and actual evapotranspiration (AET). LAI is the area of leaf which is projected over a unit of land. NEP is the difference between photosynthesis and respiration. AET is the main indicator for the water balance between the atmosphere and soil (Churkina et al. 2003).

Although Carbon is an important aspect for the growth and development of plants but another factor is the invader species in the area of previously growing plants. Study of dynamics helps to understand the strategy by which invaders react with the changing climatic conditions. On the other hand it also helps to determine the factors by which native species react to invaders. A study has been done in the Brazil (Porto Alegre City) on the dynamics and behaviour of the *Zaprionus indianus* (Gupta) member of *Drosophilidae* with respect to the native species of flora and fauna. There are three different biodiversity parks from where data has been collected. It is

concluded that the population dynamics of these species was same instead having different climatic condition and invasive species. It was the suggested that these species promoted the coexistence efficiency for the survival of native species (Silva et al. 2005).

The study of ecosystem dynamics includes the whole process by which an ecosystem is established. Therefore, it is an important issue that one should study the dynamics of micro and macronutrient precisely N, P and K. The process of K cycling is not much studied as compared to P and N. although it has essential role in the maintenance of growth of the plants. A study has been done on the dynamics of the K in the forest ecosystem considering two main aspects i. e. the availability of K in growing season and its relationship with the N. It is reported that concentration of K decreases in growing season that disturbed the biodiversity of that area and there is a strong relationship between N and K (Tripler et al. 2006).

Since it has been discussed that soil contains huge amount of carbon therefore it is necessary to study its dynamics in a broad scale so that one can have an insight about the carbon uptake with respect to the plant growth. Besides, the major problem of present day is the global warming. Carbon sequestration is one of the major alternatives to mitigate this problem (Jindal et al. 2008).

There are several methods to study Carbon cycling through its sequestering. It can be done by conventional and conservation tillage method. Conservation tillage is a good method to increase soil organic carbon (SOC) while conventional tillage disturbs soil structure that results in oxidation and loss of carbon (Lal et al, 1998). The work had been done to estimate the cost of sequestration (Pautsch et al. 2000).

Tropical forests have highest biodiversity among all ecosystems in the world. Since these are older geographical zones hence have evolved vast diversification in flora and fauna. They store large amount of carbon in their vegetation, but a little research has been done on the effect of vegetation on the carbon cycling. Studies had been done on the fluxes of carbon in Panama.

The researchers conclude that the plots having higher species diversity seems to have more carbon and lesser respiration (Jaen et al. 2009).

The reduction in the concentration of the carbon dioxide and other green house gases is the major issue of present environmental condition. United States are making sincere efforts for the reduction of GHG and carbon dioxide from the environment. It is suggested that C sequestering can help to mitigate this problem (Morgan et al. 2010).

The conservation of biodiversity is directly correlated with the conservation and restoration of forests because forest contains about 80 % of total biodiversity of terrestrial lands. Besides the efforts for forest conservation, many species are being threatened or are even extinct from their wild habitat. The main reason behind all these problems is inaccurate practices of agriculture and eradication of forests for agriculture purposes. A group of researchers have suggested the biodiversity ecosystem functioning (BEF) approach for restoration of forest ecosystems (Honnay et al. 2011).

Phenology is an important factor which contributes to overall dynamics of the ecosystem i.e. photosynthesis, nutrient uptake, seasonal changes etc. it is also essential for biological interaction and climatic changes. It has influence on variability both at the spatial and temporal level. It is basic need for the analysis of carbon sequestration and nutrient cycling (Richardson et al. 2012).

It is reported that the forest absorbs about 30% of the total carbon per year from the atmosphere since few past decades. A model suggested which conclude that global increase in the carbon will result in the increase of photosynthesis of the plants. It is predicted that this will reduce the rate of respiration. Therefore, rigid steps are necessary to conserve the biodiversity by protecting forests, parks and other areas having vast vegetation (Bellasen et al. 2014).

The main problem for extinction of many species is habitat loss and fragmentation; therefore sincere efforts should be taken into account to reduce the loss of species. One solution of this problem is to establish protected areas (PAs). Protected areas play two major role in the

protection of the biodiversity – one, they compile the data from that area which is relevant to study the species composition; second, these area restore the lost diversity of that area (Alvarado et al. 2015).

NETL (National Energy Technology Laboratory) is an organization of US department of energy. It has released its fifth edition of atlas for carbon storage. It is a safe alternative to store carbon by geologic methods (NETL article, 2015).

Gardens are good examples of a complete ecosystem because they provide a range of services to ecosystem. These services are divided into four categories i. e. provisioning services including production of food; supporting services as crop pollination and nutrient cycling; regulating services such as control of climate change and suppression of disease and socio-cultural services which includes spiritual and educational support (David et al. 2016).

PROPOSED METHODOLOGY

Proposed work will be completed by following methods:

SOIL ANALYSIS

PHYSICAL PROPERTIES OF SOIL

- Bulk density of the soil will be determined following weighing bottle method (2008).
- Determination of saturation moisture percentage following protocol given in Soil testing procedure manual (2008).

CHEMICAL PROPERTIES

- Determination of soil pH
- Organic carbon (UV Spectrophotometer Method)
- Electrical conductivity

NUTRIENT ANALYSIS

- Determination of N content following Alkaline Permegnate method as given by Subbaiah et al. (1956).
- Determination of P content following Olsen's method (1982).
- Determination of K content following procedure given by Ghosh et al (1983).

WATER ANALYSIS

Water will be analyzed for the following Characterstics:

- Determination of Sulphate on spectrophotometer following procedure given by Singh et al. 1999 (Chesnin and Yein method).
- Determination of Carbonates & Bicarbonates.
- Determination of Calcium & Magnesium following method given by Devis et al. 1970 (EDTA Titrimetric method).
- Determination of Chloride following method given by Jackson et al. (1967).

- Determination of Sodium following procedure given by Singh et al. (1999).

POT EXPERIMENT

A pot experiment will be conducted using soil from different locations to determine edaphic influence on plant growth. Similarly irrigation water from different sources will be used to determine influence of water quality on plant growth.

CARBON SEQUESTRATION

Determination of growth parameters will promote the work towards terrestrial carbon sequestration. The framework of the carbon sequestration will be done by using the manual of carbon sequestration given by US Department of Energy (1998). For carbon sequestration **BIOME BGC model** will be used.

- Diversity of the tree species will be assessed based on diversity index.

SIGNIFICANCE OF THE WORK

- Since park occupies larger biodiversity including many important plant species which provide basic niche for the fauna and different types of microorganisms hence the conservation efforts are necessary to **protect such ecosystems**.
- It will be helpful in conservation and **reintroduction** of some extinct species.
- World is facing the problem of global warming due to increase concentration of carbon dioxide and other green house gases. **Therefore it is an initiating effort towards reduction of CO_2 and GHGs.**
- Biodiversity Park has many species of flora and fauna. Each species is ecologically and economically important. Therefore this work will be helpful for survival of the species native to Agra region.
- The park is being established to provide benefit for local population therefore its conservation is necessary.

- Protected areas are the zones which provide information about the biodiversity hence these are important for educational purpose.
- Further these local efforts will provide the framework for conservation of biodiversity at broad scale and also to reduce the impact of global warming.

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